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0008

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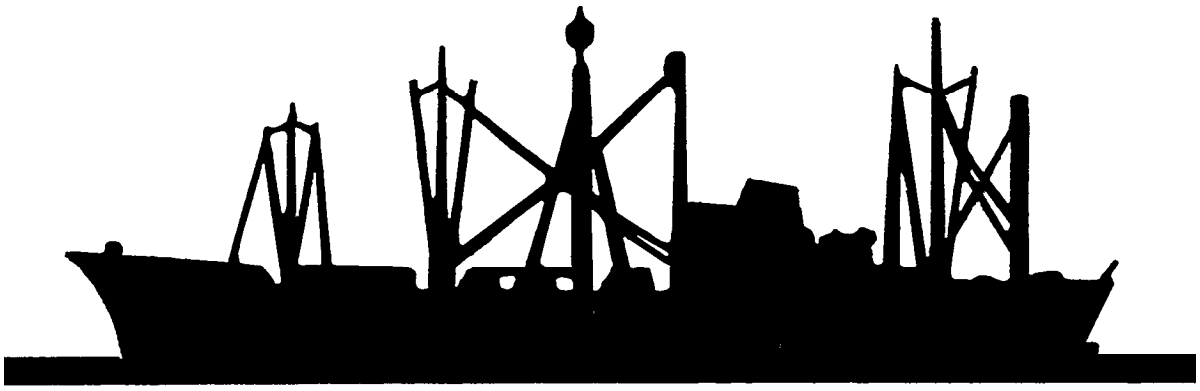

INSTITUTE FOR RESEARCH AND ENGINEERING FOR AUTOMATION AND PRODUCTIVITY IN SHIPBUILDING

IREAPS

INTERACTIVE PARTS DEFINITION PROJECT

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Newport News, Virginia

ABSTRACT

The concepts and history behind this project that will permit IREAPS shipyards to introduce interactive graphics economically into their production environment are addressed. Since the project is near completion, the uses and benefits of the deliverables are examined. On the technical side, the project accomplished some key interfaces and shipbuilding refinements.

Background:

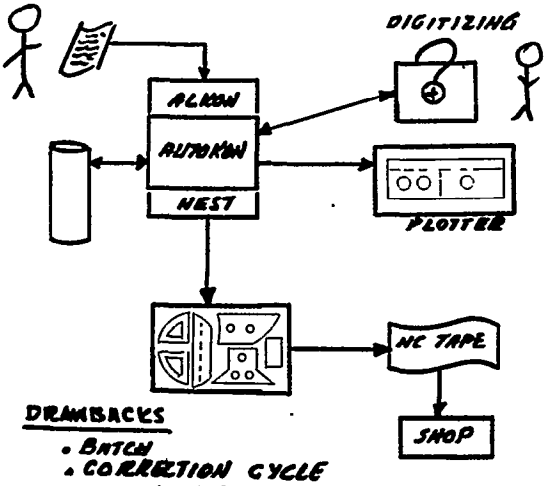
Interactive Part Definition (IPD) represents an idea which grew out of the necessity to improve current Mold Loft techniques for parts generation and nesting. As shown in figure 1, the draw backs include batch oriented programs, time consuming correction cycles, and difficult training and human factor considerations. Figure 2 shows the proposed system using interactive graphics techniques to eliminate correction cycles by on-line response and increase productivity by improved human engineering.

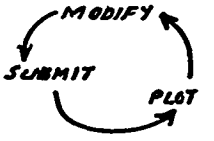
IPD has the following requirements which were defined by NNS and the IREAPS participants:

- Hardware/software package to allow users to perform real time definition of their application with visual (Graphic) output and build up a digital model of the definition at the same time.
- Must be portable and capable of being updated and expanded independently of the vendor.
- Provide a general tool to be available for future graphics projects within U.S. Shipbuilding.
- Dedicated computer hardware to provide response to support interactive graphics.
- Capable of direct interface to AUTOKON/SPADES/STEERBEAR Systems.

1

MOLD LOFT
CURRENT TECHNIQUES



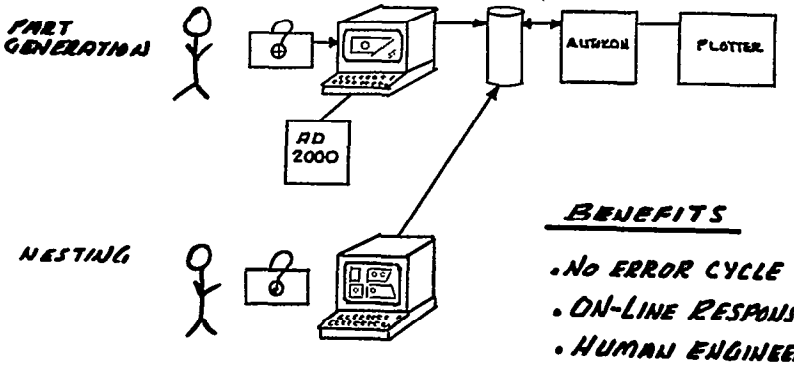


DRAWBACKS

- BATCH
- CORRECTION CYCLE
- TRAINING
- HUMAN ENGINEERING

2

MOLD LOFT
PROPOSAL



BENEFITS

- NO ERROR CYCLE
- ON-LINE RESPONSE
- HUMAN ENGINEERING

The AD2000 software system was selected as the principal element of the system. The implementation schedule for the project is shown in figure 3 and 4 as modified by vendor schedules and changes in schedule.

Status:

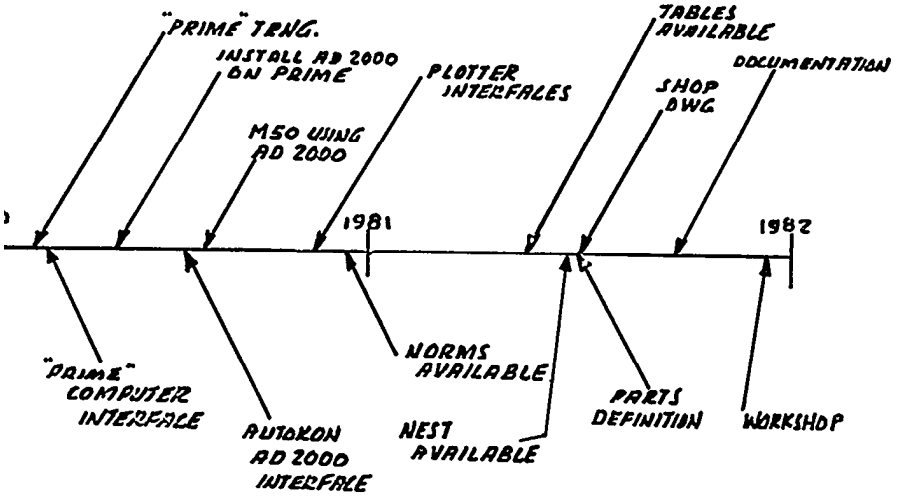
This two year IREAPS project is in its final stages of completion and has been reported on at several previous IREAPS Synposiums. The project has successfully integrated computer hardware and software to produce a graphics system tailored for the definition, nesting and annotation of ship structural parts. It furthermore permits an IREAPS member to implement this system at a relatively low cost.

Hardware Interfaces

1. Prime 750 Mini-computer

The Prime 750 was obtained to house the Parts definition Software. It was interfaced to the Honeywell 6000 main frame at Newport News via a 9600 baud link. This was done contractually by Prime, but the testing and debugging was largely done by NNS. The Prime runs as a slave to the H6000 by using the Honeywell GRTS protocol. This interface allowed us to pass files, command files (Prime jobs) and listing files from the H6000 to the Prime. Likewise H6000 job files could be passed to the H6000 from the Prime for execution. An example of this would be in sending AUTOKON parts from the H6000 to the Prime or AD2000 source listings to the H6000 page printing system.

3



4

PROJECT PLAN
PHASE II

		MONTH OF COMPLETION FROM START OF PHASE
*	ISSUE PURCHASE ORDERS	1
*	PRIME TRAINING	3
*	DEFINE DATA SPECIFICATION	5
*	AD 2000 INTERFACE	5
*	WRITE HOST ROUTINES	7
*	HARDWARE/SOFTWARE INSTALLATION	7
*	RJE INTERFACE	7
*	AD 2000 INSTALLATION	9
*	AD 2000 TRAINING	10
	MINI SEND/RECEIVE	12
	REFINE NEST	20 + 4
*	REFINE NORMS	15
*	TABLES	19
*	SHOP DRAWING CAPABILITY	20
*	REFINE PARTS DEFINITION	20
	DOCUMENTATION	23 + 4
	WORKSHOP	24 + 4

*INDICATES WORK ALREADY COMPLETE

2. Graphics Terminals

   Both slow speed data terminals and Tektranix 4014's (9600 baud) were connected to the Prime. These were installed on phone lines and modems, allowing for installations in 5 buildings around the yard. While higher speeds are desireable, no distance limitations exist in this configuration.

3. Gerber 1200 Plotter

   We could gain access to this remote plotter via the Mohawk 2400.

4. Benson-Varian 9222 Plotter

   This 22" wide, electrostatic plotter was interfaced remotely via a 9600 baud connection. We experienced some interface problems between the Prime and the 9222 controller. Compensations for this fact had to be placed in the interface software. This plotter in now settling down as a production tool.

5. Altek Digitizer

   The Altek is a send only device that connects to the Prime via a 9600 baud line. We did experience some parity problems which have been solved. This digitizer is now used in production.

6. Mohawk 2400

   This remote job entry computer is attached to the Prime via a 9600 baud line. It is likewise attached to the Honeywell 6000. It runs as a slave to the Prime and the H6000, using the GRTS protocol to talk to both. This

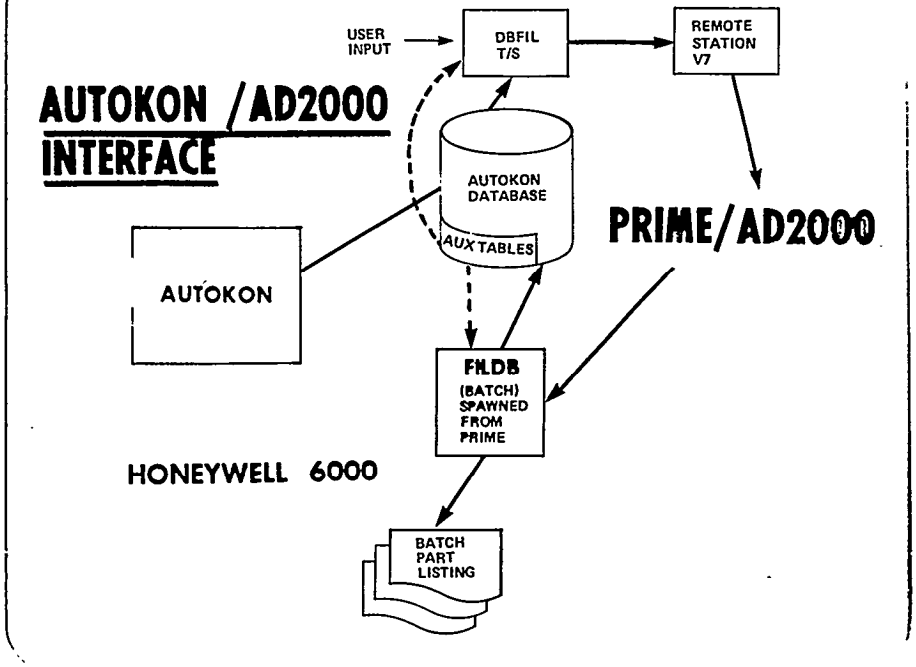
allows us to switch between both systems from our Mold Loft where it is located. This nicety came as the result of a good contract negotiation with Prime. Via the M2400, we can submit jobs to the Prime and receive back plot/punch data on tape or printed listings. This becomes our means to direct plots from the Prime to the Gerber 1200 plotter which is tape driven.

Software Interfaces:

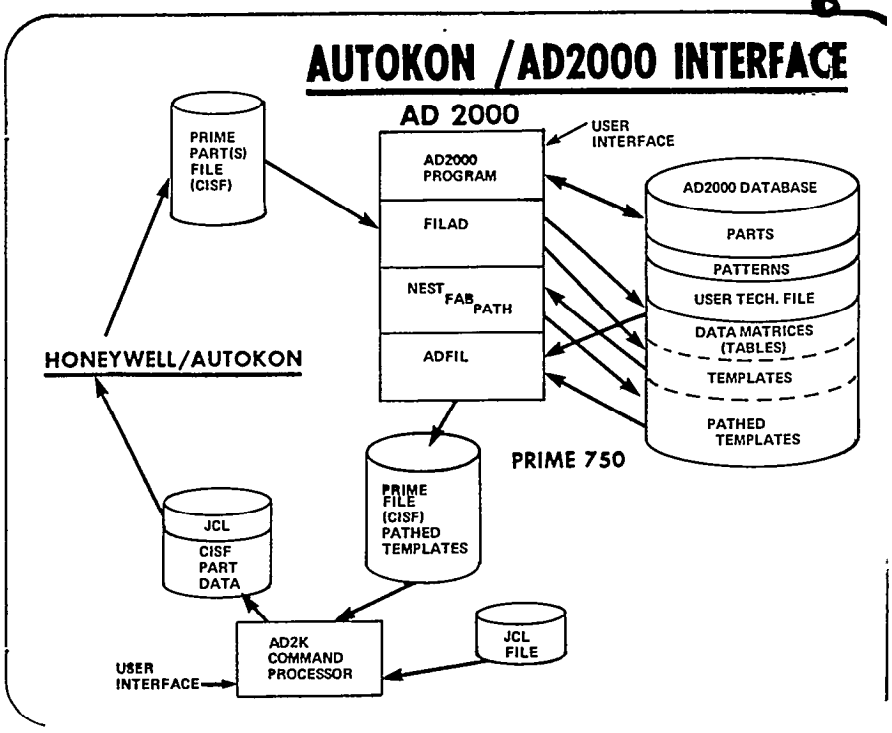
1. AUTOKON/AD2000 Interface (AUTOKON SIDE) See Figure 5

The Parts Definition project viewed AD2000 as a peripheral to a major Ship NC System such as AUTOKON, SPADES, STEERBEAR, etc. Therefore an interface to these systems was essential. At NNS we interfaced to AUTOKON, however the approach is the same to other NC Systems and much of the software can be used independently of the NC-System. Our first effort was to pass part geometry to AD2000 and back. Later we passed tabular data which encompassed all data in the AUTOKON database, including geometry. Figure 5 shows how data is extracted from AUTOKON via the interactive program DBFIL and sent to the Prime. FILDB on the other hand receives data from AD2000 on the Prime and stores it in the AUTOKON database. It is non-interactive. AUX Tables are used to determine the relationship between AUX codes in AUTOKON and Levels/Attributes in AD2000. FILDB and DBFIL are 80% AUTOKON dependent and 20% Honeywell dependent.

5


AUTOKON /AD2000
INTERFACE
USER
INPUT
DBFIL
T/S
REMOTE
STATION
V7
AUTOKON
DATABASE
AUX TABLES
PRIME/AD2000
AUTOKON
FILDB
(BATCH)
SPAWNED
FROM
PRIME
HONEYWELL 6000
BATCH
PART
LISTING

6

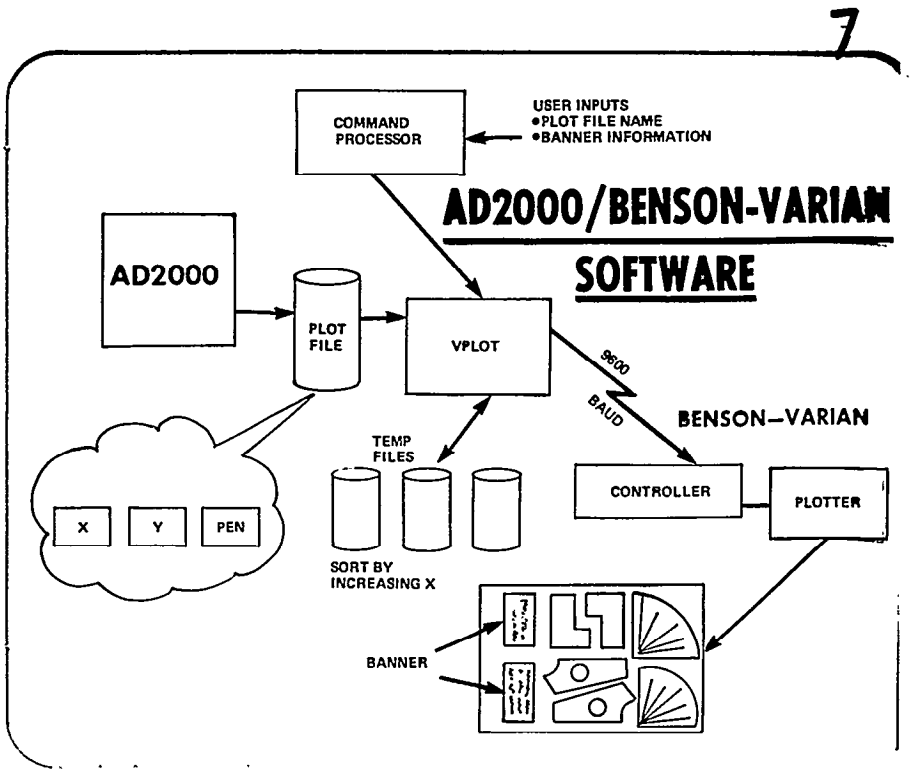

AUTOKON /AD2000 INTERFACE
AD 2000
USER
INTERFACE
PRIME
PART(S)
FILE
(CISF)
AD2000
PROGRAM
FILAD
NEST FAB PATH
ADFIL
AD2000 DATABASE
PARTS
PATTERNS
USER TECH. FILE
DATA MATRICES
(TABLES)
TEMPLATES
PATHED
TEMPLATES
HONEYWELL/AUTOKON
PRIME 750
PRIME
FILE
(CISF)
PATHED
TEMPLATES
JCL
CISF
PART
DATA
AD2K
COMMAND
PROCESSOR
JCL
FILE
USER
INTERFACE

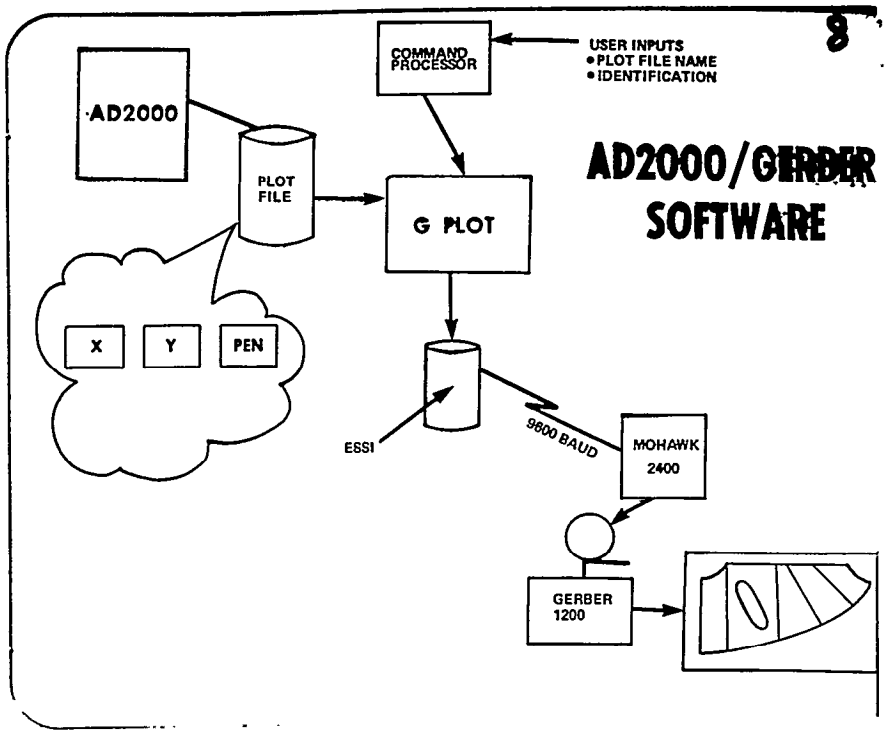
2. AUTOKON/AD2000 Interface (AD2000 Side) See Figure 6

On the Prime the data received from AUTOKON appears as an ASCII card image file called a CISF (Computer Independent Serial Format). This file can handle integer and floating point numbers with 10 digit accuracies as well as text, attributes and accounting information. The CISF was designed as a possible data exchange vehicle for shipyards who implement this system. A FILAD module in AD2000 reads the CIF and stores the data as either Templates (parts) or Data Matrices (Tables) in the AD2000 Database. Likewise the ADFIL module of AD2000 extracts data from the AD2000 database and creates a CISF file to be sent to AUTOKON on the Honeywell. Unlike FILDB and DBFIL, ADFIL and FILAD are 100% computer independent, being part of AD2000 itself.

3. AD2000 - Benson Varian Interface See Figure 7

AD2000 produces a binary plot file consisting of an X, Y coordinate and a pen code. A program was written called VPLOT to process this plot file and transmit it to the Benson Varian plotter. Since the plotter is a raster type, VPLOT must sort all geometry by increasing X values. It also provides banner information. The complete installation and development of this interface was done by Dominion Business Computers Inc. who did a good overall job for us. VPLOT is thus proprietary to Dominion, however available from them. We have found that plot files can be large and should be eventually plotted at night. While 9600 baud appears to be too slow, the software is solid.


7
COMMAND PROCESSOR
USER INPUTS
•PLOT FILE NAME
•BANNER INFORMATION
AD2000/BENSON-VARIAN
SOFTWARE
AD2000
PLOT FILE
VPLOT
9600 BAUD
BENSON–VARIAN
TEMP FILES
CONTROLLER
PLOTTER
X
Y
PEN
SORT BY INCREASING X
BANNER


8
COMMAND PROCESSOR
USER INPUTS
•PLOT FILE NAME
•IDENTIFICATION
AD2000
PLOT FILE
G PLOT
AD2000/GERBER
SOFTWARE
X
Y
PEN
ESSI
9600 BAUD
MOHAWK 2400
GERBER 1200

4. AD2000 - Gerber Interface See Figure 8

Since the Gerber 1200 at NNS already accepts ESSI formatted geometry for plotting, we chose to convert the AD2000 plot file to ESSI. The GPLOT program was written to do this and at the same time provide some user controlled optimization of pen movement. The ESSI file created by GPLOT on the Prime is then transmitted to the Mohawk 2400 for plotting on the Gerber. Although this approach works, we are unable to take advantage of the arc generation features of the Gerber since AD2000 currently only produces straight line segments. This results in large ESSI files with often some very small pen moves.

IPD Refinements:

1. NEST/FAB/PATH

This module is a second attempt to develops a module in AD2000 to provide a capability to nest ships parts, add fabrication details (bridges, leadins, etc.) and develop an optimum cutting path. The work has been done by Manufacturing and Consulting Services, Inc., the home of AD2000 under contract. The first attempt only provided for nesting. NNS personnel then developed a specification that would provide a more capable tool for part nesting, fabbing and pathing. MCS has just recently delivered their first version of this module and it will require some interactive evaluation - refinement cycles before it is acceptable.

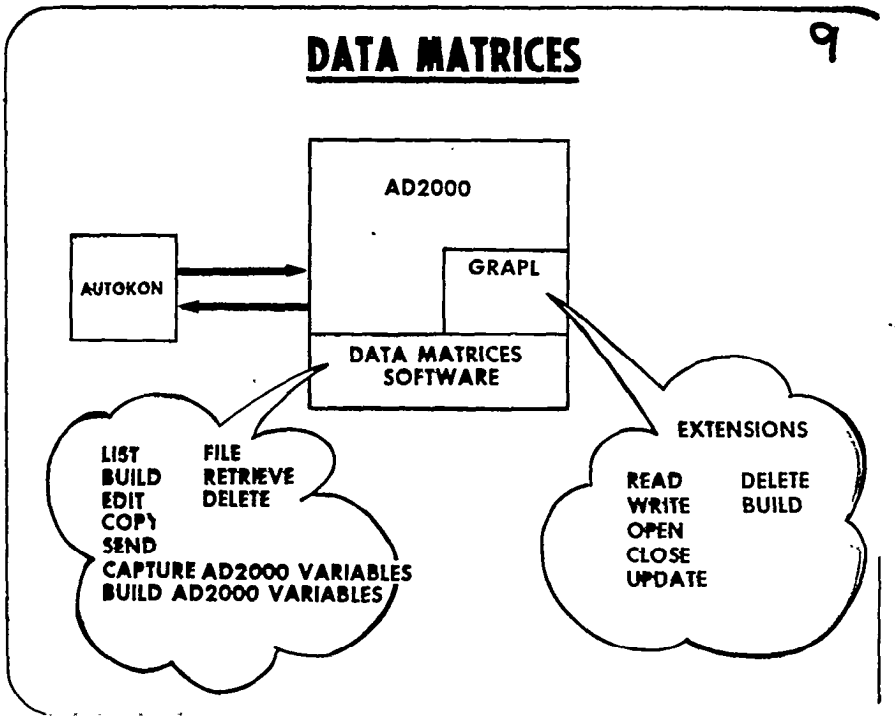
2. Data Matrices See Figure 9

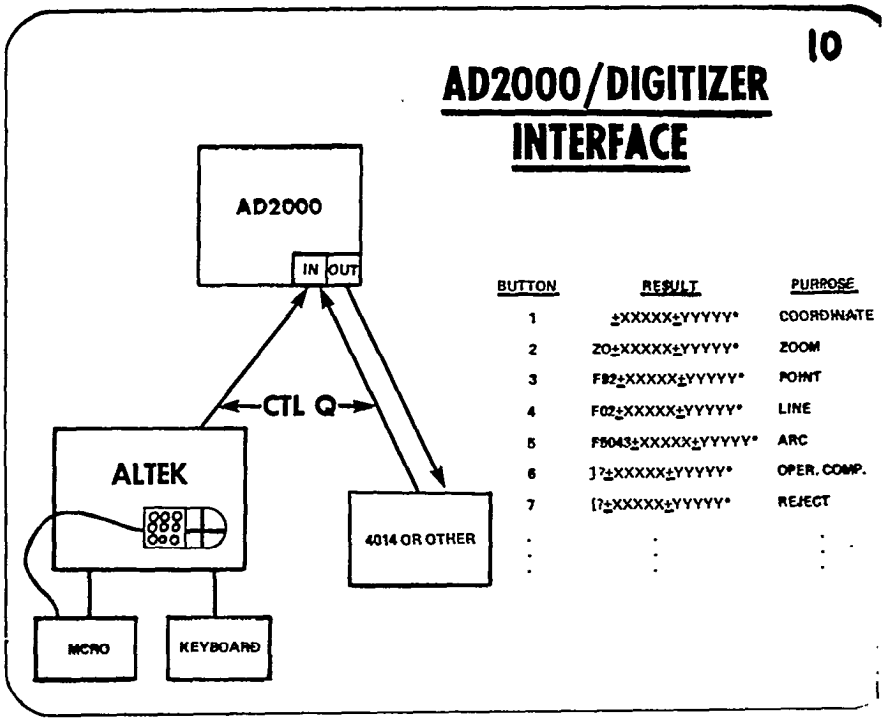
The Data Matrices capability was added to AD2000 by NNS to provide it the ability to use and manipulate tabular data similarily to the way AUTOKON does. With this capability the AD2000 user can manipulate Data Matricies interactively (Edit, Create, Copy, Delete, etc). He can move values from Data Matrices into and out of AD2000 variables. An interface to the GRAPL language (Geometric Macros) allows GRAPL to use the Data Matrices similarily to the way AUTOKON NORMS use tables or lists. Although similar to AUTOKON Tables. Data Matrices are indeed independent of AUTOKON.

3. AD2000 - Digitizer Interface See Figure 10

To allow real time digitizing into AD2000, we took advantage of the fact that the Prime allowed multiple terminals to be connected to the same program simultaneously. We also took advantage of the micro processor in the ALTEK which allowed the user to program each of the 8 cursor buttons. Data can thus be sent to AD2000 from the cursor or from an alpha numeric keyboard.

Inputs to AD2000 are switchable from the ALTEK and Tektronix 4014 by use of the 'Control Q' character which simply tells AD2000 which line to read from. AD2000 sends all of its normal outputs to the 4014. With this setup, the user can run AD2000 from the ALTEK by programming menu choices into the cursor buttons and watching the resultant geometry appear on the 4014. Figure 10 shows sample cursor


DATA MATRICES
9
AD2000
GRAPL
AUTOKON
DATA MATRICES
SOFTWARE
LIST
BUILD
EDIT
COPY
SEND
FILE
RETRIEVE
DELETE
CAPTURE AD2000 VARIABLES
BUILD AD2000 VARIABLES
EXTENSIONS
READ
WRITE
OPEN
CLOSE
UPDATE
DELETE
BUILD


10
AD2000/DIGITIZER
INTERFACE
AD2000
IN
OUT
CTL Q
ALTEK
4014 OR OTHER
MCRO
KEYBOARD
BUTTON
RESULT
PURPOSE
1
±XXXXX±YYYYY*
COORDINATE
2
ZO±XXXXX±YYYYY*
ZOOM
3
F82±XXXXX±YYYYY*
POINT
4
F02±XXXXX±YYYYY*
LINE
5
F5043±XXXXX±YYYYY*
ARC
6
]?±XXXXX±YYYYY*
OPER. COMP.
7
[?±XXXXX±YYYYY*
REJECT

button definitions. We have found this to be a very fast way of capturing geometric data, it is quickly accepted by users and requires minimal training (8 buttons to choose from). It also yields 5 digit accuracy. Since AD2000 only allows counter clockwise arcs, we developed an ability within AD2000 to define arcs in either direction which is essential for continuous digitizing. Although this implementation is highly productive, we feel it can be greatly enhanced when the users begin to write and call out GRAPL programs via the cursor buttons.

4. Multi User Databases See Figure 11

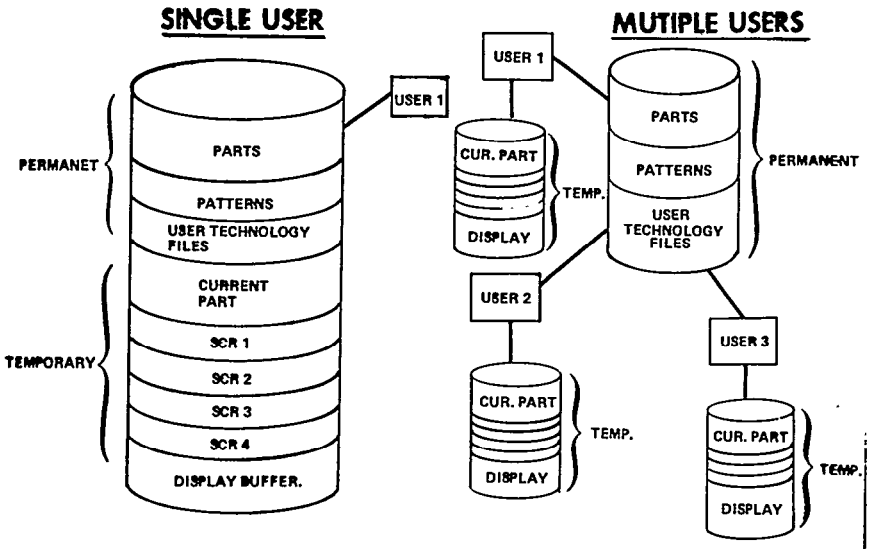
AD2000 is delivered allowing only one user to access a database at a time. However only a portion (Parts, Patterns and User Technology Files) retain permanent information. The rest of the database is temporary storage for the current session. NNS devised a scheme such that each user would be assigned his own temporary storage area and share the permanent area with other users via an attach-access-detach sequence. This has worked quite nicely since it was installed early in the IPD project.

5. GRAPL See Figure 12 and 13

GRAPL is a Graphics Macro language suppllied by MCS that permits the AD2000 user to write parametric driven routines using a graphics language for standard geometric shapes. It is a Family of Parts tool similar to AUTOKON NORMS in its purpose. Figure 12 gives an example of one GRAPL program used to create three different results. When

11

DATA BASES



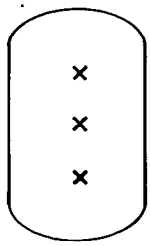
12

SAMPLE GRAPL PROGRAM

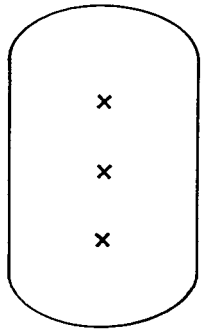
TEXT

```
1  SIZE, ARG(5)
2  REMARK/HOLE 102 SIMULATED NORM KWP
3  REMARK/ARG1, ARG2, ARG3-CNTX,Y,Z
4  REMARK/ARG4, ARG5-DEPTH, HEIGHT
5  PARAMS/'KEY IN 5 ARGS',5 ,2 'XCEN',2, 'YCEN',2, 'ZCEN',
6  2, 'DEPTH',2, 'HEIGHT', IDUM,ARG(1), STAT
7  REMARK/DO CALCULATIONS
8  PT1-POINT/ARG(1), ARG(2), ARG(3)
9  PT2-POINT/ARG(1), ARG(2)+ARG(5)-ARG(4), ARG(3)
10 PT3-POINT/ARG(1), ARG(2)-ARG(5)-ARG(4), ARG(3)
11 RAD1-ARG(4)/2
12 CIR1-CIRCLE/CENTER, PT2, RADIUS, RAD1, COANC, 0, ENDANG, 180
13 CIR2-CIRCLE/CENTER, PT3, RADIUS, RAD1, COANC, 180, ENDANG, 0
14 LIN1-LINE/RIGHT, TANTO, CIR1, RIGHT, CIR2
15 LIN2-LINE/LEFT, TANTO, CIR1, LEFT, CIR2
16 STOP
```

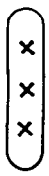
RESULT 1



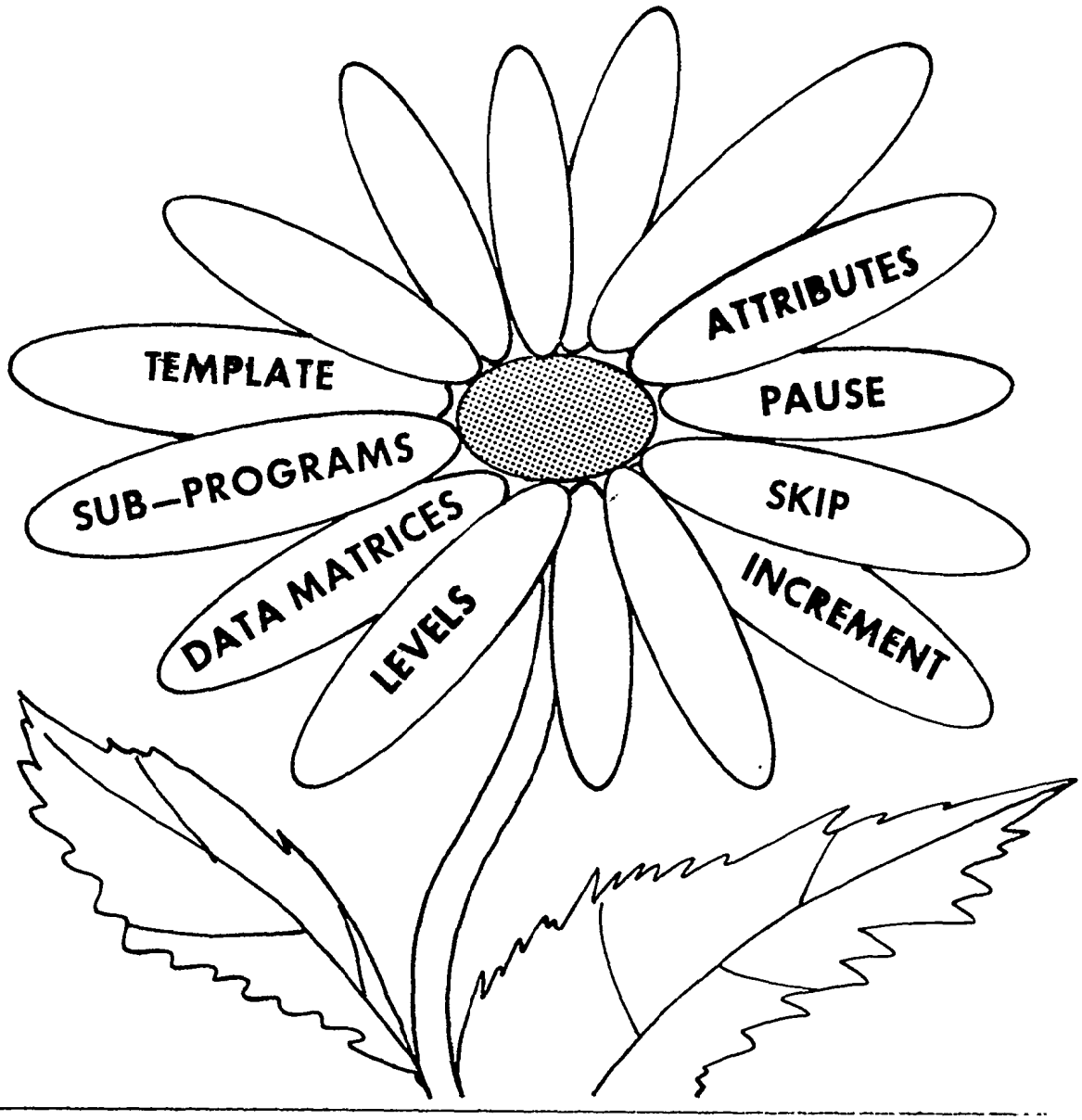
RESULT 2



RESULT 3



IPD GRAPL ENHANCEMENTS



obtaining AD2000, NNS developed contractual specifications that would make GRAPL more useful to Shipbuilding than it was. These include

a. Templates - Templates (ship parts) can be retrieved and soon filed in the database.

b. Subprograms - A GRAPL program can be stopped and resumed after other AD2000 tasks are performed, including the execution of another GRAPL program.

c. Data Matrices - Discussed previously.

d. Levels - GRAPL programs can create geometry on any level desired.

e. Attributes - Attributes can be assigned to entities by GRAPL.

f. PAUSE - SKIP - INCREMENT - The user can exit and resume a GRAPL program, skip executable statements or increment a statement at a time.

g. Cursor - A GRAPL program can ask the user to select geometry by using the cursor device.

On the whole NNS pushed MCS to develop an interactive graphics language so that a user organization could write its own graphics applications without dependence on a computer programmer. We at NNS see many users for GRAPL in our future developments.